We claim:

1. An apparatus, comprising an optical fiber having at least three distinct, concentric cylindrical regions 1, 2 and 3 having corresponding refractive indices of n_1, n_2 and n_3 and corresponding diameters d_1, d_2 and d_3, where $n_2>n_1>n_3$ and $d_3>d_2>d_1$ and at least one of these regions contains an optically active rare earth ion.

2. The apparatus of claim 1, further comprising means for optically pumping said optical fiber, said apparatus further comprising means for coupling signal light into said optical fiber to be amplified.

3. The apparatus of claim 2, wherein said means for optically pumping said optical fiber includes a laser diode or laser diode array.

4. The apparatus of claim 2, wherein n_1, n_2 and n_3 and d_1, d_2 and d_3 are chosen to provide a fundamental optical mode at the wavelength of said signal light such that the electric field of said fundamental optical mode at the center of said cylindrical regions is approximately the same strength as the electric field at the outer edge of region 2.

5. The apparatus of claim 1, wherein said optical fiber is further surrounded by a region with refractive index $n_4 < n_3$ to provide a multi-mode waveguide.

6. The apparatus of claim 1, wherein the cylindrical symmetry of region 3 is deliberately broken via de-centering of region 3 from regions 1 and 2 or by altering the outside shape of region 3.

7. The apparatus of claims 1, wherein the optically active rare earth ion is selected from one of the following Yb^{3+}, Nd^{3+}, Sm^{3+}, Tm^{3+}, Er^{3+}, Ho^{3+}, Dy^{3+} or Pr^{3+}.

8. The apparatus of claim 1, wherein said optical fiber comprises fused silica in region 3 and fused silica with germinia, phosphorous, fluorine or alumina in regions 1 and 2.

9. The apparatus of claim 1, wherein n_3 is nominally the index of fused silica, $n_2=n_3+0.002$ and $n_1=n_3+0.001$ and $d_1=24.4$ μm, $d_2=30$ μm and d_3 is in the range of 80 to 1000 μm.

10. The apparatus of claim 1, wherein n_3 is nominally the index of fused silica, $n_2=n_3+0.002$ and $n_1=n_3+0.001$ and $d_1=44.72$ μm, $d_2=50$ μm and d_3 is in the range of 80 to 1000 μm.

11. The apparatus of claim 1, wherein said rare earth ion is confined to region 1 or a concentrically located sub-region of region 1.

12. The apparatus of claims 1, wherein said fiber is preferentially wound around a cylindrical mandrel of radius R, where R is chosen such that there is minimal bend induced attenuation for the desired waveguide mode propagating in the core of the fiber, but significant attenuation for all other modes at the signal wavelength.

13. The apparatus of claim 1, wherein said signal pulse comprises an ultrashort pulse, said apparatus further comprising means for temporally stretching said signal pulse prior to coupling said signal light into said optical

fiber, wherein the stretched pulse is greater than 10 times longer in time than said signal pulse.

14. The apparatus of claim 2, further comprising means for providing feedback to said apparatus.

15. The apparatus of claim 14, wherein means for providing feedback include at least one mirror configured to reflect a portion of light emitted optical fiber back into said optical fiber.

16. The apparatus of claim 14, wherein said means for providing feedback includes at least one optical isolator.

17. The apparatus of claim 2, further comprising a Q-switch operatively positioned to produce a pulsed output from said optical fiber.

18. The apparatus of claim 2, further comprising polarizers and polarization control elements operatively positioned to achieve mode-locking, the apparatus further comprising a parallel grating pair operatively balance cavity dispersion.

19. The apparatus of claim 2, further comprising a non-linear crystal provided at the laser output in order to frequency double the laser output.

20. The apparatus claim 2, further comprising a non-linear crystal configured for sum frequency generation.

21. A method, comprising:

providing an optical fiber having at least three distinct, concentric cylindrical regions 1, 2 and 3 having corresponding refractive indices of n_1, n_2 and n_3 and corresponding diameters d_1, d_2 and d_3, where $n_2>n_1>n_3$ and $d_3>d_2>d_1$ and at least one of these regions contains an optically active rare earth ion;

optically pumping said optical fiber; and

coupling signal light into said optical fiber to be amplified.

22. The method of claim 21, wherein the step for optically pumping said optical fiber includes optically pumping with a laser diode or laser diode array.

23. The method of claim 21, wherein n_1, n_2 and n_3 and d_1, d_2 and d_3 are chosen to provide a fundamental optical mode at the wavelength of said signal

light such that the electric field of said fundamental optical mode at the center of said cylindrical regions is approximately the same strength as the electric field at the outer edge of region 2.

24. The method of claim 21, wherein said optical fiber is further surrounded by a region with refractive index $n_4<n_3$ to provide a multi-mode waveguide.

25. The method of claim 21, wherein the cylindrical symmetry of region 3 is deliberately broken via de-centering of region 3 from regions 1 and 2 or by altering the outside shape of region 3.

26. The method of claims 21, wherein the optically active rare earth ion is selected from one of the following Yb^{3+}, Nd^{3+}, Sm^{3+}, Tm^{3+}, Er^{3+}, Ho^{3+}, Dy^{3+} or Pr^{3+}.

27. The method of claim 21, wherein said optical fiber comprises fused silica in region 3 and fused silica with germinia, phosphorous, fluorine or alumina in regions 1 and 2.

28. The method of claims 21, wherein said fiber is preferentially wound around a cylindrical mandrel of radius R, where R is chosen such that there is minimal bend induced attenuation for the desired waveguide mode propagating in the core of the fiber, but significant attenuation for all other modes at the signal wavelength.